Polarization measurements with rotating disk electrode for characterization of the degradation of Mg-Gd and Mg-Ag binary alloys

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Abstract

Magnesium (Mg) and its alloys are interesting metals for biodegradable temporal implant application because they have a similar density and stiffness compared to cortical bone. Mg also plays a role in bone healing, it is potentially non-toxic, biocompatible and biodegradable. Mg alloying elements have to be chosen in an application specific way, taking into account that different resorption rates can be needed for different applications keeping the mechanical integrity until its function is completed. For this reason, silver (Ag) and gadolinium (Gd) have been selected as alloying elements. Ag is known as an antibacterial agent and accelerates resorption due to the large galvanic potential difference with Mg [1]. Mg-Gd alloy is reported as a slow degrading material with superior mechanical properties[2, 3].

Potentiodynamic polarization (PDP) experiments give a comparison of the behaviour of different alloys by assessing the current density at the corrosion potential applying the Tafel extrapolation, which can be translated into a corrosion rate [4]. During polarization, the influence of unstable hydroxide layers typically formed on magnesium and its alloys are suppressed with the help of a rotating disk electrode (RDE) giving reproducible results [5-7]. In this way the very first degradation rate can be measured and compared between alloys.

This work compares PDP measurements of as-extruded samples of Mg-Ag (2w%, 4w%, 6w%) and Mg-Gd (5w%, 10w%, 15w%) with pure Mg and Mg4Y3RE as reference material in phosphate buffered saline (PBS) at 37˚C in static and dynamic conditions. The measured current densities are higher with RDE than in static conditions because of the lack of corrosion layer protection. This method gives more repetitive results and a representation of the material during the first degradation process.

Keywords: magnesium degradation, electrochemistry, rotating disk electrode (RDE), potentiodynamic polarization (PDP), Mg-Gd, Mg-Ag, phosphate buffered saline (PBS)

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